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Automated Queue Management System

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Chapter 1

I. Introduction

a) Background

Nowadays, customer service oriented companies facing difficulties of lengthy queues. These problems often occurred in the banks, post office and airport and it became worsen when the time reached peak hour. The improper management of such queues will cause tension and stress among customers and employees. Customers will tend to shift to other service companies that provide better services and it reduced job satisfaction of the employees.

According to Bain & Company net, a global management –consulting firm, "a customer is four times more likely to defec to a competitor if the problem is service related than price or product related". Moreover, Lee Resources International net, a general business consulting stated that for "every customer complaint there are 26 other unhappy customers who have remained silent". Thus, any companies need a provide good services in order to attract customers to attain sustainability doing business.

In general, queuing is a line of people waiting to be serve and the movement is from a central to a specific place. Thus, a queue management system must handle and organized queue formation in the most efficient way.

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b) Problem Statement

Many companies provide queue management system for controlling queues of people in various situations and locations in a queue area. Most of the techniques used are manually for a small space and simple flow. On the other hand, automated queue management system deal for a larger space and complex flow. These can be see widely used in banks, hospitals or clinics and post offices.

Bylayat, Nahid, Moqbull and Habibur (2011) had designed a Microcontroller Based Electronic Queue Control Systems. The aim of that designed systems is to maintain a queue with order and efficiency. There are two different queue control systems which have been implemented with slightly different queue control systems which have been implemented with slightly different features in the research which are EQC system-1 and EQC system-2, EQC system-1displays token number and service counter number whereas EQC system-2 display token number individually in each service counter with separate displays.

The fundamental of the designed system is similar like the one, which has been use broadly todays in queue area. The flexibility is that customers have the flexibility of being processed by more than one service point and service points possess the capability of processing more than one customer class. However, the system cannot integrate to the number of customers per certain time. The sytem cannot change and remain it is when there are not much customers in the waiting area and when there are crowded of customers in the waiting are.

Therefore, the purpose of this research is to design and built an automatic queue management system that has more flexibility when dealing with its surrounding.

c) Research Objectives

The aim of this research is to develop an Automated Queue Management System in a way that solve queuing problems. The objectives of this project to:

1) Investigate the current approaches for queue management system.
2) Design a working system for automated queue control system.
3) Implement the system using mechatronic solution.
4) Evaluate the system for effectiveness.

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d) Research Questions

The study is conduct based on these two research questions:

1) Which surrounding should be use as model to develop an automatic queue management system?
2) What are the parameters should take in order to achieve optimal performance in queue system?

e) Project Scope

The Automated Queue Management System is design to manage certain customers with single department and multiple counters. There are three operations, which customers can choose i.e. Service A, Service B, Service C and three customer counters that provide services i.e. Counter 1, Counter 2 and Counter 3. The related information of this system will be displayed at the display module i.e. Liquid Crystal Display and sound module i.e. Buzzer.

f) Research Methodology

g) Gantt Chart

Chapter 2

II. Literature Review

a) Introduction

A queue management system is the organization of queues of people within a retail or public sector department. It can be either reactive through a system that can organize the existing queue or proactive through queue management statistics gathering system, so that the trends can be identified and anticipated. People that join queue in a standing line queue are direct to the next position by the system or be given issued with a ticket. With a ticketed system, customers are took out of the standing line queue, which can give comfort and less stress for the customers as well as their turns are not neglect. This queuing environment is and essential part of our daily lives and it is important for manufacturer to build the most cost-effective queuing solution.

b) Types of Queue

There are two types of queue, which are structured and unstructured queues. Structured queue is a queue in a fixed form and people that included are in predictable position. We can see this at supermarket paying counter and some other retail locations such as banks and post offices. This type of queue systems often being set up to manage ticket ranking for a service with identification and thus enable a stress-free waiting. Extending the different possibilities, some of this system is planned reception by appointment or remotely rank allocation on Smartphone or through SMS.

Whereas, unstructured queue is where people form a queue in unpredictable and varying locations and directions. This is often the case in some forms of retail, taxi queues, ATMs and at period of high demand in many situations. Some of the existing solutions are rank allocation for service, pages or RFID badges or simply by reading the customer card. In fact, it is hardly to implement a way of structuring these queues to be successful. The reason is that one cannot easily calculate the behavior of man.

c) Queue Management Techniques

Various queue management techniques exist are physical barrier, signage and signaling systems and automatic queue measurement system.

Physical barrier is aim at guiding queue formation and organizing it in a neat way. While signage and signaling systems are aim to provide information to people, queuing and aid efficient queue formation flow as well as setting service expectations. Differently, automatic queue measurement system uses a variety of measurement technologies, which predict and measure lengths and waiting times, which provide management information to help service levels and resource deployment.

d) Queue Management Concept

Many researches have done previously on the queue management concepts such as Shortest Processed First 9SPF), First Come First Serve (FCFS), Singe Queue (SQ), Multiple Queue (MQ), Diffuse Queue (DQ) and Head of Queue (HQ).

SPF works as scheduling policy that choose lesser time execution to process first. In a supermarket, a specific paying counter only process transaction which customer buying goods less than 10 goods. SPF can work well because of its simplicity and minimizes the average amount of waiting time for each process. However, the setback is that it requires long time to complete if short process are continually add and customers do not perceive the right degree of fairness from the system. It is important to explain why customers are being serve in that order and ensure the understanding of customers to see the logic of this alternative approach.

On the other hand, FCFS is a method that deal the oldest entry being process first. FCF's behavior is where people leave the queue in the order, which they arrive. It is the most fairly service provision where all customers think of themselves as equal.

The single queue, SQ is the familiar snake format. Each person waiting is serve in turn and the format discourages pushing in. The queue also provides visible reassurance to customers that they will be serve fairly while the queue is progressing.

Besides that, the multiple queue, MQ is the improvement of SQ, it is essential to use this method when handling larger amount of people. This queue is the format that always being use at the supermarket.

Other than that is the diffuse queue, DQ, which has no formal queue line but customers registr place in

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the process with a ticket. Figure 2.1 is the example of using this method.

Last is the head of queue, HQ, which place the next person to be serve waits in a single queue environment. This method is significant when the number of checkout is higher than five. It is vital that customers able to see along the line of service position to avoid significant gaps in service provision. In order to maintain fairness in this system, there are several rules have been set:

- Queue must be fair and be managed systematically that cannot allowed to descend into a chaotic situation.
- Perception of waiting time should be manage.
- The process must be clearly identify; start and ends must be visible.
- The process must include positive feedback of progress.

e) Advantages of Queue Management System

Queue management system gives benefits either to customer service provider or to the customer itself. The benefits can be directly or indirectly to the system. There are:

- Keeps track and forecast the flow of customers.
- Optimum utilization of staff forecast.
- Constant monitoring the staff's performance.
- Enhance productivity and morale of the staff, as operation were efficient and systematic.
- Gives flexibility in dealing with customers.
- Increase service reliability, as customers are treated fairly and efficient.
- Producing statistical reports, which facilitate top management's decision making process.

f) Eisting Queue Management System

There are many products available on the market produced by many queue management companies for delivering optimum customer service, which are Stand Alone Queue System and Centralized Control Queue System.

i. *Stand Alone Queue System*

Stand Alone Queue System (SAQS) design based on First Come First Serve, FCFS queue model, where there is only one service counter operation. All customers will be manage at the single counter. This system operates by calling or displaying number in sequential or randomized order and the customers will be treat fairly. The SAQS is performing well in a single department, service operation environment such as clinic.

ii. *Advance Queue System*

Advance Queue System (AQS) based on SAQS design where additional service counters are add to give flexibility in queue system process. This system can support up to 32 service counters and additional of 60 counters. It also can provides useful queue features as well as comprehensive reports. Besides that, it allows manager of real-time monitoring status for the queue management analysis. AQS is performing well in bank, hospital or any organization that has multiple department service operation.

iii. *Centralized Control Queue System*

Centralized Control Queue System (CCQS) design is use for higher range of customers in different department. This system has the capability to support up to 20 departments which each department can have up to 32 service counters and 60 counters. CCQS is network compatible because each department has been located at different part of a building or even in geographical area. Thus, CCQS is connect through LAN or Internet and it also provide real-time status monitoring.

g) Customer Flow Management

There are few manager of service provider know what happens with their customers throughout the whole interaction process in real-time. If the supply and production managers know the flow of material and product in detail, why does not the head of operations know the flow of customers equally well? Is the flow of customers less important than the flow of material and products? Is the flow of customers more difficult to monitor and control? By knowing absolutely the customers is a key success factor for any service provider that wants to be competitive. Therefore, Customer Flow Management (CFM) is managing the flow of customers and their experience from initial contact to final service delivery.

The Customer Flow Management process consist of several phases including pre-arrival, arrival, queuing or waiting, serving, post-serving and managing as illustrated in figure 2.14. It is view of the entirety of the customer service operation, the resulting framework for making informed business decisions and the frames the boundaries of CFM.

i. *Pre-arrival*

CFM can start before the customers physically visits the shop or service center by implementing a method to book appointments before arrival. This reduces the time spent waiting by the customer and produce a positive impact on the customer's service experience.

ii. *Arrival*

Customers need to be place in an appropriate queue on arrival. Customer Flow Management stresses the possibility of segmenting the customers in different queues rather than entering all customers in the same queue.

iii. *Queuing/waiting*

Most customers will endure a period of waiting after queue entry. A balanced and controlled waiting period is the desired optimum results of any managers.

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No one wants to have a completely empty waiting area as it reflected that you are overstaffed or impression of abandonment. Equally, too many customers waiting is simply as off-putting. In the case of a hospital or public service center, certain citizens might not accept it as they can demonstrate this during elections. CFM can help managers get the balance rightly by improving staff planning and by adding more flexibility to the process.

iv. *Serving*

When calling the customer forward, staff can start preparations if the service chooses to identify and tracking customer's history before the customer actually arrives at the service point.

v. *Post-serving*

After a customer has been serve, a case handling function can continue to manage the case throughout its lifetime if needed and each step is document and process.

vi. *Managing*

Managers can uses the gathered data in CFM process to evaluate the current processes. Reports can be generate on employee-customer interactions, service times and customer wait times. Operational inefficiencies can be identified and addressed through process changes or training.

Chapter 3

III. System Design

a) Conceptual Design

Banks have been one of the major units of the public for the past years. Many researchers try to develop new technology in order to increase customer satisfaction. Thus, an active research should be focuses on analyzing the queues to optimize their operations, which customer's waiting time can be reduce.

In this research paper, an automated queue control system has been develop for organizing queue in banking for a low-cost and efficient way. The system can analyses the queue status and take decision which customer to serve, as the factor of the average waiting time is take into consideration.

b) System Design Overview

The scenario of the proposed system can be described as shown in the Figure 2.1. Customer will select required services either Service – A, Service-B or Service-C and gets an acknowledgement receipt. The receipt consists of information like token number, service selected, date, time and retail or organizational name. The customer proceeds towards the service counter when his token number displayed on the screen. Therefore, instead of worrying about their places in the line, customers can relax and have a great customer service experience.

The automated queue control system can be divide into several process. First, customers will select require service and proceed to the waiting area. The system will records the customers token number with the type of service selected. Then, the system will analyzes the data collected and decides customers turn to be serve. At the waiting area, a display will be place and shows customers token number and service counter number that indicate which customer to be serve next. Lastly, different display located at the different service counter will display current customer's token number which is now being serve.

c) Component Selection

i. *Intel Galileo Gen-2*

The Intel Galileo board is a microcontroller board based on the Intel Quark soC x 1000 application processor, a 32-bit Intel Pentium brand system on a chip (soC). It is the second-generation board based on Intel Architecture design to be hardware and software pin-compatible with shields designed for the Arduino Uno R3.

In addition to Arduino hardware and software compatibility, the Intel Galileo board has several PC industry standard I/O ports and features to expand native usage and capabilities beyond the Arduino shield ecosystem. A full-sized mini-PCI Express slot, 12V power-over-Ethernet (PoE) capable, Micro-SD slot, 6-pin FTDI header, USB host port, USB client port and 8 Mbyte NOR Flash come standard on the board.

ii. *Push-Button*

A push-button is a simple switch mechanism for controlling some aspect of a machine. It is usually made of hard material likes plastic or metal. To accommodate the human finger or hand, the surface is usually flat. The push-button is required for this project as input from the arriving customers and as the control pendant at the service counter.

iii. *Liquid-Crystal Display*

A liquid –crystal display (LCD) is a flat panel that uses the light modulating properties of liquid properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images or fixed images which can be display or hidden, such as preset words, digits and 7-segment display as in digital clock. They use the same basic technology, except that arbitrary images are made of a large number of pixels, while other displays have larger elements. For this project, LCD is use for displaying token number at ticket counter, waiting area and service counter.

iv. *Buzzer*

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke. For this project, buzzer is use for alarming which indicate of next customer service at the service counter.

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v. *Ds307 Real-Time Clock Module*

The DS1307 Real-Time Clock is a low power, full binary-coded decimal (BCD) clock plus 56 bytes of NV SRAM. The clock provides seconds, minutes, hours, day, date, month and year information. Address and data are transferred serially via a 2-wire, bi-directional bus. The DS1307 has a built-in power sense circuit that detects power failures and automatically switches to the battery supply. Meanwhile, the DS1307 happens to possible the getting of customers arrival time data. which is important for the system analysis.

vi. *PCF8574N*

The PCF8574N is an 8 bits I/O port expander that uses the 12C protocol, which communicates using a 2-wire seria interface i.e. one wire is a serial clock (SCL) and the other is for serial data (SDA). The reason for choosing the PCF8574N is to minimize the using of Galileo ports for LCD's circuitry.

d) Complete Circuit

All the hardware components are connect together as shown in the figure below.

e) Bill Of Material

Table 3 : Bill of Material

Component	Bill	Expected Price (RM)
Intel Galileo Gen-2	1	RM 245.00
LCD (16x2)	4	RM 80.00
PCF8574N	4	RM 32.00
Wire Jumper	100	RM 13.60
Trimpot 10K	4	RM 8.00
DS1307RTC Module	1	RM 6.30
Plastic Container	1	RM 5.90
6x6x1 Push Button 4 Pin	6	RM 3.30
Screw and Screw PCB Stand	4	RM 2.80
Buzzer 6-12v	1	RM 3.00
Resistor 10kΩ	8	RM 0.40
Total		RM 400.30

Chapter 4

IV. Result and Discussion

a) Analysis on Input Module

i. *Push Button*

There are total of six push buttons used for connecting the Galileo. The pins used are digital pin 2 to digital pin 7. Push buttons for digital pin 2, 3 and 4 used for collecting data from customers. They will choose either service A, B or C. In contrast, push buttons for digital pin 5, 6 and 7 are place at the service counter. Teller will use it to call for next customer to provide require service.

The way a push button works with Galileo is that when the button is pushed, the voltage will goes Low, which in turn Galileo read this and reacts accordingly. A pull-up resistor is use to keep the voltage HIGH when the push button is not being press. In other words, a small amount of current is following between VCC and the input pin (not ground). thus the input pin reads close to VCC.

ii. *DS1307 RTC Module*

The DS1307 RTC module works very well in keeping the time. However, the external temperature can affect the frequency of the oscillator circuit, which drives the DS1307's internal counter. This may sound like a problem, however it usually result with the clock being off by a round five or so minutes per month. Besides that, proper ventilation is use for the container in this project.

b) Analysis on Output Module

i. *LCD*

A standard 16x2 LCD is use but using just two pins. The way it can achieve by the PCF8574, an I/O expander that communicates with Galileo by 12C. With this IC, two ports of Galileo can control up to eight digital I/O ports. In the 12C protocol, each IC has different address. In this project, first four of the address is use as there are four different LCDs used.

ii. *Buzzer*

A piezo buzzer will makes a small "click" when voltage is applying to it. If the voltage is turn on and off hundreds of times per second, the piezo buzzer will produce a tone. Then, if a bunch of tones is string together, it will produce a music. Simple music will ring when a service counter calls a customer.

c) Algorithm Development

i. *Rule Based System*

Rule based system is a system. which problems can written in the form of IF-THEN rules. The problem are usually is not large. If there are too many rules, the system can become difficult to maintain and can suffer a performance hit.

In this project, there are three rules will be looking at before deciding which one will be implemented in the system. There are:

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1) Rule 1: All service counters are multipurpose type.
2) Rule 2: Service counter 1 only for customer choosing Service-A.
3) Rule 3: Each service has one service counter.

In addition, two parameters set for all the rules, which are Service-A, B and C have duration to complete 60sec, 120sec and 180sec respectively. The second parameter is that customer is assume to follow this arrangement: "customer-A customer-B customer-C customer-A customer-B customer-C…"

Figure 4.4 shows that Rule 1 is the least time consuming to finish all the customers and thus the rule will be use throughout this project.

ii. *Queuing System Model*

This part presents a different technique for queue management system in banks proposed by Ahmed and Huda (2011). The technique can build an automated queue control system by using the DQ concept. To select the next customer to be serve during a specific period, the system chooses and appropriate algorithm among more than one scheduling algorithm, which are FCFS and SPF.

Moreover, to achieve the best waiting time for all the customers that are waiting to be serve, it is depend on the testing result for selecting the scheduling algorithm. To achieve this, additional components to the traditional queue management system are need.

- Customer Area

In customer area, customer selects required service at the ticket counter and waits until the ticket number shown in a display.

- Queuing Area

In queuing area, the system chooses one of the waiting customers by using the queuing algorithm that is choose by the testing area.

- Testing Area

In testing area, the system test and compare all the result for the expected waiting and response time then selects the best algorithm.

- Scheduling Algorithm Database Area

All the needed scheduling algorithms, the testing result and the number of customers are stored in this area. The testing result and the customer's numbers are save temporarily.

- Service Area

In service area, the system serves the customer according to the different services that a bank can gives such as transaction, open account and balance. Each service has their own specific time.

iii. *Result Analysis*

To test the performance of the new proposed system, several simulations were carry. A randomized generated number is use to generate a sequence of customer's arrival time and option of services that they can choose. The different services are open an account, transaction and balance with the period of each services which are 15, 10 and 5 minutes respectively.

In this proposed system, two scheduling algorithm are used which are FCFS and SPF. Differs to the ordinary system (FCFS) which is usually being use in the most of the banks queuing system. The proposed system will test the queuing system using testing algorithm every specific period, consider in this research to be 15 minutes. Then, make comparison of the results of waiting time and average waiting time. The results shown in figure 4.5 and figure 4.6 respectively.

FCFS

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12

Fig. 4.6 : Ordinary Queuing System Gantt chart

a. Testing first 15 minutes using the two scheduling algorithms

FCFS

C1	C2	C3	C4	C5

0 15 20 35 50 60

SPF

C1	2	C5	C3	C4

0 15 20 30 45 60

b. Testing 2nd 15 minutes using the two scheduling algorithms

FCFS

C6	C7	C8	C9

60 15 20 35 50

SPF

C6	C7	C8	C9

60 65 70 75 80

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c. Testing 3rd 15 minutes using the two scheduling algorithms

FCFS

C9	C10	C11	C12

75 80 90 100 105

SPF

C6	C7	C8	C9

75 80 85 95 105

Fig. 4.7 : The New Queuing System Gantt chart (a, b, c,d)

Through the extensive experiments conducted, the primary goal is to determine the ability of the new queuing system against the ordinary queuing system. Figure 4.7 shows that the new approach decreases the average waiting the time compared to the ordinary queuing system while Table 3 shows the average waiting time for the ordinary queuing system and the new queuing system.

Table 5 : The Average Waiting Time Comparison between the Ordinary Queuing System and the New Queuing System

Time Slice	Average Waiting Time and Algorithm (Ordinary Queuing System)	Average Waiting Time and Algorithm (New Queuing System)	Difference the between Ordinary and New Algorithm
1st Group	16.4/FCFS	14.4/SPF	2
2nd Group	42.5/FCFS	42.5/FCFS	0
3rd Group	47/FCFS	43.66/SPF	3034
Total Average Waiting Time	32.75	31.083	1.667

Equation 1 used to calculate the waiting time for each customer and Equation 2 used to calculate the average waiting time for each group of customers (Willin, 1999).

$$CWT\ I = SSTC\ I - ATC\ I$$

Where:
CWT is a Customer Waiting Time
SSTC is a Start Serving Time for a Customer
ATC is Arrival Time for a Customer
I is the number of customer

$$AWT = (\Sigma CWT\ i)/TN$$

Where:
AWT is Average Waiting Time
CWT is a Customer Waiting Time
TN is total number of customer served
i is the number of customer

Chapter 5

V. Conclusion and Recommendation

a) Conclusion

Design and development of Automated Queue Management System starts with the understanding of the queue system itself. which is very crucial to broaden the horizon of understanding. Then, the consideration of the control strategy and component to be use plays important role as guidelines to accomplish this project.

In addition, several articles have been review to investigate the current approaches for queue management system. Although the current approaches have proven to ease and give benefits to service providers, yet there are space of improvement in order for a queue system function efficiently.

Besides that, the early queue system design for this FYP (implemented using mechatronics solution) has been present on the chapter 3 and several analysis were carry on the chapter 4 of this report.

b) Limitation

The assumption of the queuing theory may be too restrictive to be able to model real-world situations exactly. The mathematical models often assume infinite number of customers, infinite queue capacity or constant inter-arrival or service times (same service type), when it is quite apparent that these bounds do not exist in reality. In other words, the theoretical solution may prove insufficiently informative to be useful.

c) Recommendation

There are some improvement can be made such as addition of sensors of cameras that can detect customers at a certain time. This method can improve the efficiency of a queue system as it alerts manager to counter fast on the situation. Lastly, the system can being made to become a product as in this project only being made as for research and learning.

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